Keo SkyScan

Control Software

Software User Manual

Version 0.9
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1 Introduction

Thank you for purchasing Keo SkyScan Control Software (SSCS, or “the software”) for use with your Keo Scientific SkyScan articulated mirror assembly. This software provides an easy way to control your SkyScan system both manually and in advanced modes of operation.

At this point in time, the software supports two different modes of operation: Manual and Heliostat. The manual mode allows you to move to a specified position or jog one of the axes. Heliostat mode allows you to specify your geographic location and a start time and end time and it will track the sun. For developing custom applications to control the SkyScan, please refer to the command set detailed in the Hardware User Manual.

If at any point you have a question about SkyScan Control Software or need technical support to resolve an issue, please don’t hesitate to contact us using the contact information found in Section 6.1.

1.1 Changes from Previous Versions

Changes from previous versions of the software are briefly described here from the newest to oldest release.

1.1.1 Version 0.9.0

This was the initial public beta release of the software. It serves as the baseline version to which all later version improve upon.

2 System Requirements

2.1 Software Requirements

Keo SkyScan Control Software is a Microsoft Windows based application that will run on any 32-bit or 64-bit version of Windows provided it is newer than Windows XP Service Pack 3. This includes Windows XP, Windows Vista, and Windows 7.

The software also requires the Microsoft Visual C++ 2010 Redistributable Package (x86). The application installer will check for this dependency when it is run and if it isn't already installed it will download it and install it for you. Should this fail for any reason, you can manually download and install the package here:

http://www.microsoft.com/en-us/download/details.aspx?id=5555

For the purposes of this manual it is assumed that you have successfully installed the device drivers required to communicate with the SkyScan system. Please refer to the SkyScan4 Hardware User Manual for details on setting up the system.

Note

If you will be running the SkyScan autonomously (e.g. in heliostat mode), it is recommended that you disable the Windows Update feature so that the computer isn't automatically restarted. You can do this in Windows 7 by navigating to

Control Panel > *Windows Update* > *Change Settings*

and changing the *Important Updates* drop down to *Never check for updates*.

The procedure is similar for Windows XP and Vista.

2.2 Hardware Requirements

SkyScan Control Software supports all Keo SkyScan systems manufactured on or after January 2012. If you are uncertain when your SkyScan system was manufactured, please contact Keo Scientific.

The only computer hardware requirement is an available USB2 port. If the host computer can run the operating system installed on it then it should be able to run the SkyScan Control Software. If you have any concerns regarding whether your computer will be able to run the software then please feel free to contact Keo Scientific with your concerns.

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3 Installation

After your SkyScan system has been installed and configured as per the instructions in the Hardware User Manual, the next step is to install the SkyScan Control Software.

1. Insert the SkyScan Control Software CD into your computer and navigate to the optical drive in Windows Explorer or alternatively locate and download the installer from our FTP site (ftp://ftp.keoscientific.com).
2. Now launch the SkyScan_Control_Software-X.Y.Z setup executable. Note that the X.Y.Z string on the end of the filename is the version of the software.
3. The installer will walk you through the installation.

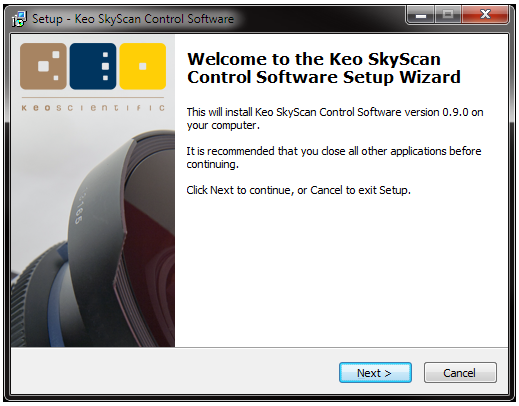
Setup - Keo SkyScan Control Software
Welcome to the Keo SkyScan Control Software Setup Wizard
This will install Keo SkyScan Control Software version 0.9.0 on your computer.
It is recommended that you close all other applications before continuing.
Click Next to continue, or Cancel to exit Setup.
Next >
Cancel

Figure 1: Installation

4. When the installation is complete, you will have the option to launch the software immediately.

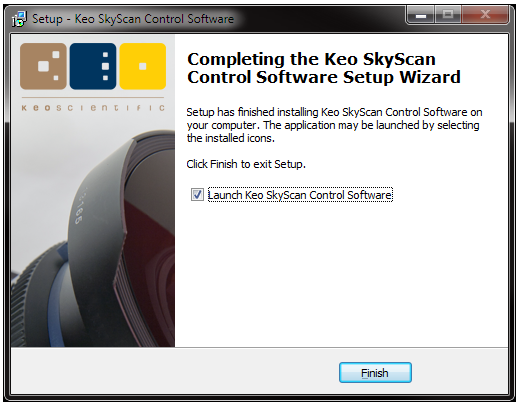
Setup - Keo SkyScan Control Software
Completing the Keo SkyScan Control Software Setup Wizard
Setup has finished installing Keo SkyScan Control Software on your computer. The application may be launched by selecting the installed icons.
Click Finish to exit Setup.
Launch Keo SkyScan Control Software
Finish

Figure 2: Installation Complete

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4 Application Overview

4.1 Starting the Application

To launch the application, either double-click the icon on the desktop or navigate to and click on the Windows start menu entry.

Start Menu > All Programs > Keo Scientific Ltd > SkyScan Control Software > Keo SkyScan Control Software

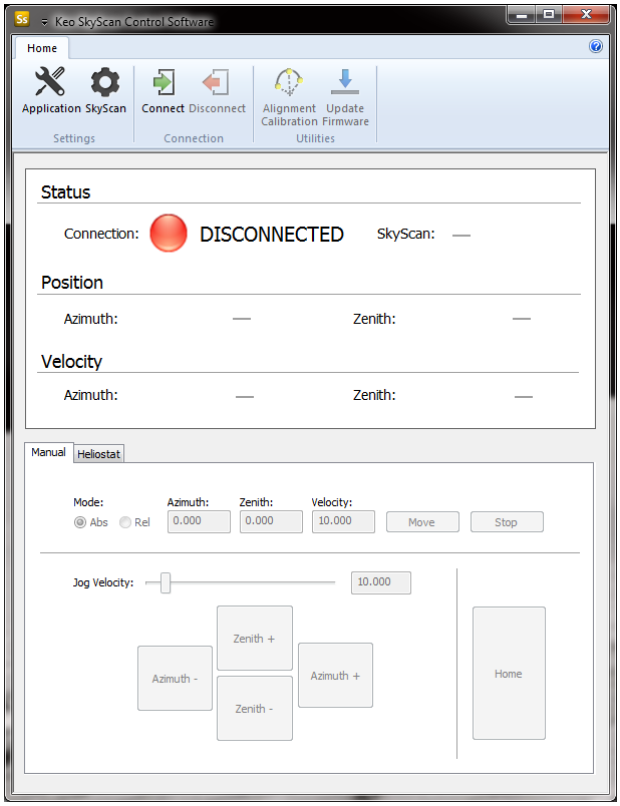

Figure 3: Main Application Window

The **Main Application Window** can be broken down into 3 main areas: the **Ribbon Toolbar** at the top, the **Status Pane** in the middle, and the **Control Tabs** at the bottom. There is also an **Error Notification Bar** that will appear between the **Ribbon Toolbar** and **Status Pane** in the event of any errors.

4.2 The Ribbon Toolbar

The **Ribbon Toolbar** consists of several buttons that perform a variety of tasks. The buttons are grouped into three distinct panels or sections: **Settings**, **Connection**, and **Utilities**.

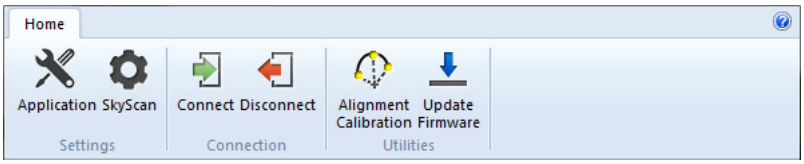

Figure 4: The Ribbon Toolbar

4.2.1 Settings Pane

This section of the **Ribbon Toolbar** allows you to change the application and SkyScan settings.

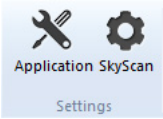

Figure 5: Settings Pane

The 'Application Settings' Button

This button launches the **Application Settings Dialog**. This dialog lets you change the style of the ribbon, set the logging level, and open the log folder. Clicking **OK** from this dialog will save the settings and close the dialog while clicking **Cancel** will discard any changes and close the dialog.

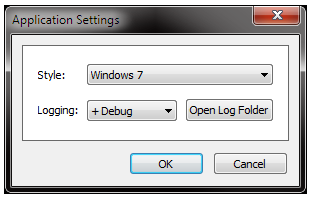

Figure 6: Application Settings Dialog

The **Style** dropdown lets you select a ribbon style to use in the application. Select whatever option you feel looks best. This option defaults to *Windows 7*.

The **Logging** drop down lets you change the level of logging done to the log file. The default option, **Normal**, will just log normal operating messages as well as any warnings or errors encountered. Changing this option to **+ Debug** will result in additional debug information being logged.

Important Information

This additional debug information will be useful to Keo Scientific while debugging any problems you may have.

In the event of you encountering an error you think is an application bug, please change this option to **+Debug** and repeat the sequence of events that reproduce the error in question. Then send the log file to Keo Scientific along with a detailed description of the sequence of events leading up to the issue.

This option should remain at **Normal** under most operating conditions to prevent the log file from growing to a very large size.

The **Open Log Folder** button will open Windows Explorer and change to the log file folder. This path is defined as:

%ProgramData%\Keo Scientific Ltd\SkyScan Control Software\logs

Each time the SkyScan Control Software application is started a new log file is created with a timestamp (in UTC time) of the startup time. The format of the filename is as follows:

YYYY-MM-DD_hh-mm-ss_SystemLog.log

where:	**YYYY**	The year
	MM	The month (01 = January)
	DD	The day of the month
	hh	The hour (UTC)
	mm	The minute (UTC)
	ss	The second (UTC)

The 'SkyScan Settings' Button

This button launches the **SkyScan Settings Dialog**. This dialog lets you change any available SkyScan settings. Clicking **OK** from this dialog will save the new settings and close the dialog while clicking **Cancel** will discard any changes and close the dialog.

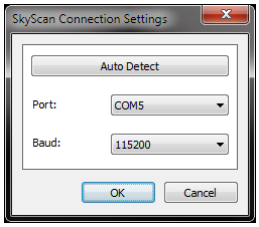

Figure 7: SkyScan Settings Dialog

The **Auto Detect** button will launch a dialog that will attempt to automatically detect the SkyScan.

> **Note**
>
> The 0.9 release of SkyScan Control Software does not have this feature implemented.

The **Port** drop down box lets you pick the serial port the SkyScan is connected to.

The **Baud** drop down box lets you select the baud rate to use when communicating with the SkyScan. This defaults to **115200** and should never need to be changed. Changing the baud rate would require new SkyScan firmware and changing the settings in the Bluetooth adaptors.

4.2.2 Connection Pane

This section of the **Ribbon Toolbar** allows you to connect or disconnect from the SkyScan.

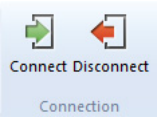

Figure 8: Connection Pane

At any given time, only one of the two buttons on this pane will be enabled. When connected to the SkyScan, the **Connect** button will be disabled (greyed out) and when not connected the **Disconnect** button will be disabled. The current connection status is prominently displayed in the **Status Pane** of the **Main Application Window**.

The 'Connect' Button

This button will take the settings defined in the **SkyScan Settings Dialog** and attempt to connect to the SkyScan. If the connection is successful then the rest of the application will become active and you will be able to control the device.

If the connection attempt fails a few different things could happen depending on the reason it failed.

- If the serial port couldn't be opened because it is either already open in another program or it doesn't exist anymore (e.g. the SD1000U Bluetooth USB adaptor has been detached from the computer), you will get a message similar to the one in Figure 9.

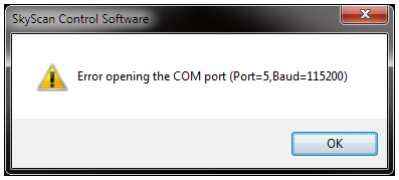

Figure 9: Error Opening Serial Port

- If a SkyScan device was not found on the serial port you will get a message similar to the one in Figure 10. This indicates that either the **Port** selection in the **SkyScan Settings Dialog** is incorrect or the SkyScan is not powered on.

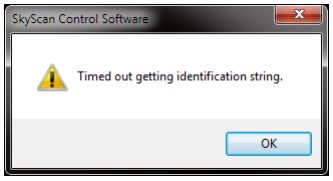

Figure 10: SkyScan Not Found

The 'Disconnect' Button

This button will simply close the SkyScan serial port. Since you are now not connected to the SkyScan, the rest of the application will become disabled to prevent you from trying to control the SkyScan.

4.2.3 Utilities Pane

This section of the **Ribbon Toolbar** allows you to launch several different utilities.

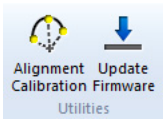

Figure 11: Utilities Pane

The 'Alignment Calibration' Button

This button will launch the **Alignment Calibration Dialog** which allows the user to perform an alignment calibration. Details on this dialog can be found in Section 5.2.

The 'Update Firmware' Button

This button is currently not implemented. In a future release it will launch the **Firmware Update Dialog** which allows for the user to easily update the SkyScan firmware without having to follow the steps outlined in the SkyScan Hardware User Manual.

4.3 Status Pane

This section of the **Main Application Window** displays a variety of information about the SkyScan. This pane is consists of three different sections: **Status**, **Position**, and **Velocity**.

When in the disconnected state, everything will be disabled and the **Connection Status** will be **DISCONNECTED** as shown in Figure 12.

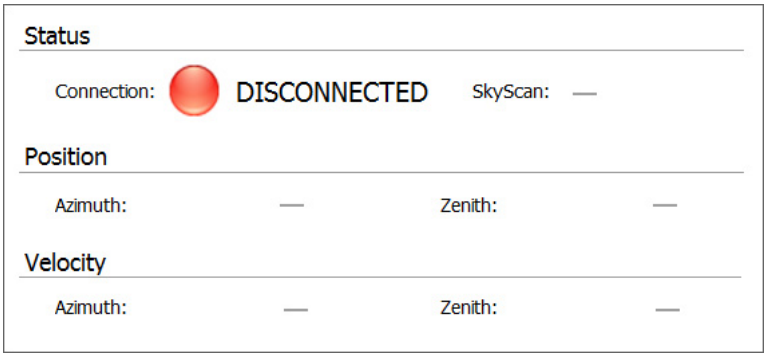

Figure 12: Status Pane – Disconnected

When the software is connected to the SkyScan, the **Connection Status** will become **CONNECTED** (as in Figure 13) and various pieces of information regularly updated.

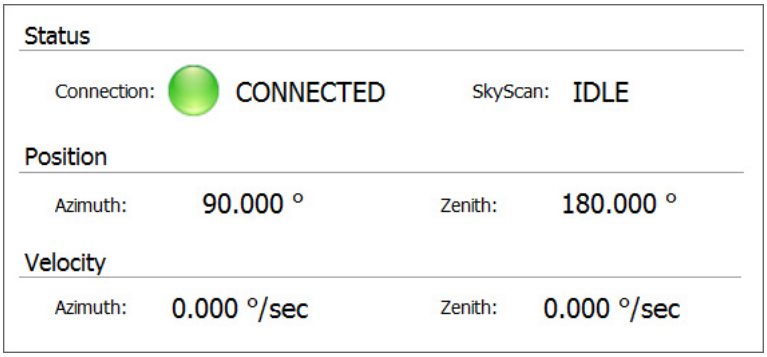

Figure 13: Status Pane – Connected

The **SkyScan Status** value indicates the current status of the SkyScan device. This is usually one of the following, although under certain conditions it could be a combination of multiple statuses.

Status	Description
IDLE	In the idle state with no active routines.
HOMING	Running a homing routine.
MOVING	Running an absolute or relative move.
JOGGING	Running a velocity move.
WAITING	Waiting for a trajectory to start.
TRAJECTORY	Running a trajectory.
UPLOADING	Uploading a new trajectory.

The **Position** section displays the current position of the axes. If an alignment calibration has been completed then the positions shown here will be in global geographic coordinates, not the local SkyScan coordinates.

The **Velocity** section displays the current velocity of the axes.

Note

The **Velocity** values are not valid when running a trajectory – this should be fixed in a future version of the software.

4.4 Control Tabs

These tabs at the bottom of the **Main Application Window** are what you will use to control the SkyScan. At this time there are two tabs: **Manual** and **Heliostat**. As is implied with the tab names, the **Manual** tab contains various ways of manually controlling the SkyScan, and the **Heliostat** tab contains the necessary controls for operating the SkyScan in heliostat mode.

4.4.1 Manual Control Tab

The **Manual Control Tab** contains various ways of manually controlling the SkyScan, whether it be commanding an absolute or relative move, a velocity move, or running a homing routine.

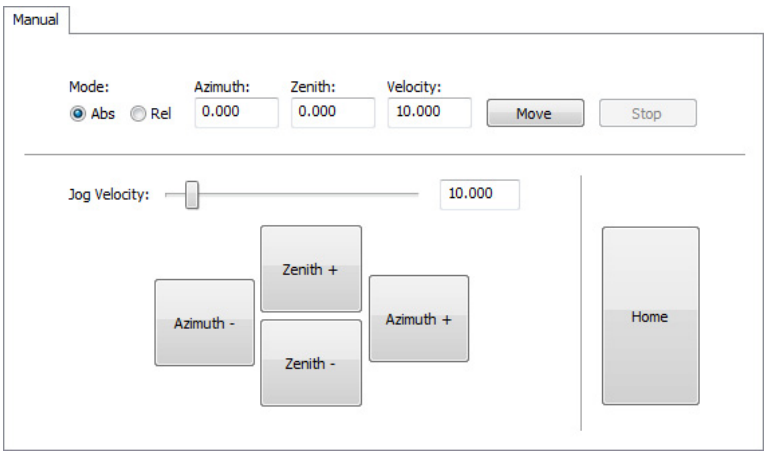

Figure 14: Manual Control Tab

The first section at the top allows you to specify the move mode (either **Abs**olute or **Rel**ative), the destination position (**Azimuth and Zenith**), and the velocity to move there at (**Velocity**). After entering the

values, click the **Move** button to start the move. Click the **Stop** button at any time to stop the SkyScan mid-move.

> **Note**
>
> After an alignment calibration has been done, the destination positions specified should be in the global geographic (earth) coordinate system. The software will automatically convert those into SkyScan local coordinates.

The section below that allows you to do a velocity move, i.e. a move where an axis is moved at a constant velocity until commanded to stop. This is done a single axis at a time (you can't have both axes moving at the same time) and is useful for slowly 'jogging' the different axes. Simply specify the axis velocity using the **Jog Velocity** slider or entry box and then **left-click** and **hold** on one of the four direction buttons. To stop the jog move, simply **release** the left mouse button.

The **Home** button on the right side will start a homing routing on the SkyScan. While this is in progress the rest of the controls will be disabled.

4.4.2 Heliostat Control Tab

The **Heliostat Control Tab** is what is used to control the SkyScan in heliostat mode to track the sun. See Section 5.1 for an in-depth discussion on the functionality of this mode of operation.

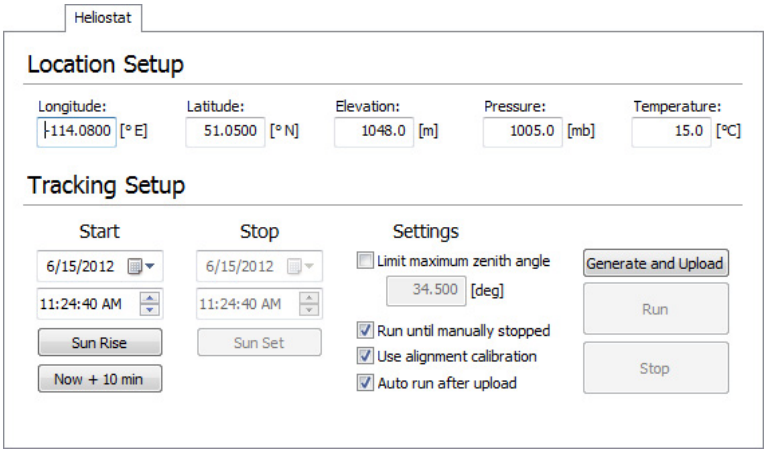

Figure 15: Heliostat Control Tab

4.5 Error Notification Bar

Whenever an error occurs in the application the **Error Notification Bar** will appear below the **Ribbon Toolbar**. This notification bar informs you that errors have occurred and provides a button for opening the log file to inspect the errors. You can close this bar at any time by clicking on the 'X' on the far right hand side.

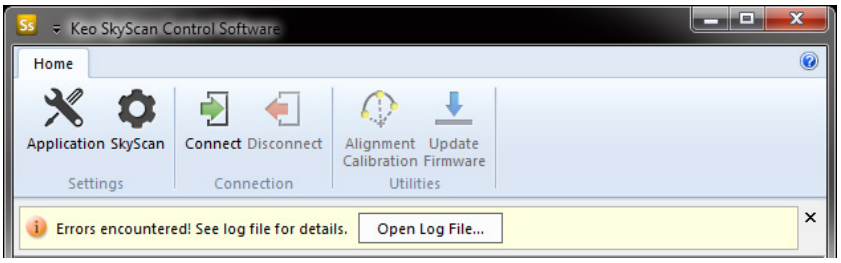

Figure 16: Error Notification Bar

5 Advanced

In general the operation of the software is fairly straight forward and the descriptions in the previous section are sufficient to educate the user on how to use the software. This section provides additional direction for the advanced modes of operation and utilities available in the software.

5.1 Heliostat Mode

The software can operate in what is known as **Heliostat Mode**. This mode allows for precise tracking of the sun over the course of a day (or many days). This is accomplished by uploading a pre-calculated trajectory to the SkyScan for each day of operation. The SkyScan then uses this trajectory to track the sun with no input from the host computer.

Heliostat Mode of operation is controlled using the **Heliostat Control Tab** which is part of the **Control Tabs** section on the **Main Application Window**. This tab is broken into two main sections: the **Location Setup** section and the **Tracking Setup** section.

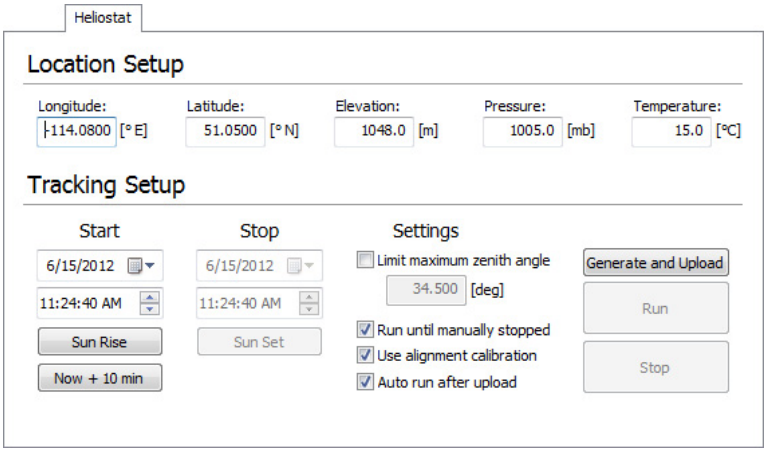

Figure 17: Heliostat Control Tab

5.1.1 Location Setup

This section contains the five required location parameters used in calculating the sun ephemeris.

Parameter	Description
Longitude	The longitude of your location in degrees, negative west of Greenwich.
Latitude	The latitude of your location in degrees, negative south of the equator.
Elevation	The elevation of your location in meters, negative below sea level.
Pressure	The local atmospheric pressure in millibars. Set to 1000 if unknown.
Temperature	The local average temperature in degrees celcius.

Of these five parameters, only the first three (longitude, latitude, and elevation) are critical in calculating the position of the sun. The other two parameters (pressure and temperature) are only used for calculating atmospheric refraction near the horizon.

5.1.2 Tracking Setup

This section is where you will define your tracking settings. There are three sections of settings: the **Start Time**, the **Stop Time**, and **Settings**.

In **Heliostat Mode**, sun rise/set times refer to the apparent rise or set of the upper limb of the sun's disk. By reason of atmospheric refraction, the upper limb of the sun is actually below the horizon at the instant of its apparent rise or set.

5.1.3 Start Time

As implied in its name, the **Start Time** is the time you would like the sun tracking trajectory to begin. This time must be after the current time and should be set to allow for upload time which can be upwards of 5 minutes for full day trajectories.

There are two preset time buttons, **Sun Rise** and **Now + 10 min**, that let you load a calculated time into the **Start Time** selection box and use that as the **Start Time**. The **Sun Rise** time will calculate the sunrise time for the day selected in the date selection box. The **Now + 10 min** button is an easy way to set the time to 10 minutes from now.

Note
The **Start Time** only applies to the day the trajectory is started. If a multi-day trajectory is defined then the **Start Time** on all days after the first day will be defined by the sun rise time on that day (the **Maximum Zenith Angle** setting can be used to modify the defined rise/set angle).

5.1.4 Stop Time

The **Stop Time** can be set to any time after the **Start Time**. If it is on a different day than the **Start Time** then tracking will stop at sunset (or the **Maximum Zenith Angle** setting) and resume the next day.

The **Sun Set** button will calculate the sunset time for the day selected in the date selection box and use that as the **Stop Time**.

Note
The **Stop Time** only applies to the day the trajectory ends. If a multi-day trajectory is defined then the **Stop Time** on all days before the final day will be defined by the sun set time on that day (the **Maximum Zenith Angle** setting can be used to modify the defined rise/set angle).

5.1.5 Settings

This section has a few settings that can be changed to customize the behavior of the sun tracking trajectory.

Limit Maximum Zenith Angle

The **Limit Maximum Zenith Angle** setting allows you to specify a custom rise/set elevation of the sun. Enabling this setting and entering a zenith angle would change the start and stop times so that the SkyScan doesn't track the sun when the zenith angle is greater than the one specified. For example, using 80 degrees as the maximum zenith angle would alter the start and stop times such that tracking starts when the sun rises over a 10 degree elevation and ends when it drops below a 10 degree elevation.

Unchecking the **Limit Maximum Zenith Angle** setting is equivalent to leaving it checked and using a **Maximum Zenith Angle** of 90 degrees.

> **Note**
>
> The trajectory will start when both the **Start Time** and **Maximum Zenith Angle** criteria are met. i.e. the trajectory will only start if the current time is later than the **Start Time** and the sun is above the **Maximum Zenith Angle**.
>
> E.g. 1: It is currently 8:02am and the sun is at a zenith angle of 82 degrees (8 degrees above the horizon). You selected a **Start Time** of 8:10am and a **Maximum Zenith Angle** of 85 degrees. The trajectory will not start until both the **Start Time** and **Maximum Zenith Angle** criteria are met so the actual start time will in this case be the **Start Time** selected (8:10am).
>
> E.g. 2: It is currently 9:02am and the sun is at a zenith angle of 82 degrees. You selected a **Start Time** of 8:00am and a **Maximum Zenith Angle** of 80 degrees. The trajectory will not start until both the **Start Time** and **Maximum Zenith Angle** criteria are met so the actual start time will be the time when the sun moves above 10 degrees of elevation.

Run Until Manually Stopped

This setting will disable the **Stop Time** controls. The SkyScan will run a new trajectory each day until stopped with the **Stop** button.

Use Alignment Calibration

This option will take all the calculated trajectory points (which are in the global geographic coordinate system) and transform them into the local SkyScan coordinate system using the alignment calibration data. This option should always remain checked unless you are performing an alignment calibration.

> **Note**
>
> If you haven't done an alignment calibration yet there is no harm in leaving this option selected because the transformation is simply a 1:1 mapping.

Auto Run After Upload

This option will automatically start the trajectory after the upload is complete. This is equivalent to clicking the **Run** button manually after the upload is complete.

5.1.6 Control Buttons

The buttons on the right-hand side of the **Heliostat Controls Tab** are used for controlling **Heliostat Mode**.

The 'Generate and Upload' Button

After the necessary settings have been configured, click the **Generate and Upload** button to generate the trajectory and upload it to the SkyScan. A progress bar will appear at the bottom of the **Heliostat Control Tab** indicating the upload progress.

> **Note**
>
> The upload process can take a while (up to several minutes) if uploading a full day's trajectory. This is why the **Start Time** must be 5 minutes after the start of the upload process.

The 'Run' Button

The **Run** button can be used to start the trajectory if the **Auto Run After Upload** option is not used. Clicking this button after an upload has finished will initialize the SkyScan trajectory by waiting until 10 seconds before the start of the trajectory and then moving to the starting position.

The 'Stop' Button

The **Stop** button will perform a variety of tasks depending on the current state. If a trajectory is currently being uploaded, it will cancel the upload. If the trajectory has been initialized (with the **Run** button or automatically after uploading) but hasn't started yet then this will cancel the wait and the trajectory will never start. If the trajectory is currently running then this button will stop the trajectory.

Note
At this time there is no way to resume a trajectory after it has been stopped. You will have to generate, upload, and run a new trajectory.

5.2 Alignment Calibration

Depending on your application, it may or may not be critical that your SkyScan be precisely aligned with the Earth's geographic coordinate system. An alignment calibration system has been built into the SkyScan Control Software that, after running the calibration, will translate all global coordinates into the local SkyScan (misaligned) coordinates. This is crucial for obtaining the highest accuracy from the system.

This translation allows for you to specify all positions to point at in the global coordinate system and they will be automatically transformed into the local SkyScan coordinate space.

5.2.1 Alignment Calibration Overview

The software uses the sun to perform a pseudo three star alignment of the system. The general idea is that you will use the SkyScan in heliostat mode to track the sun over a period of time. During this period of time you will capture three data points, each of which will contain 5 values:

1. The timestamp of the data point,
2. The azimuth position of the sun in the global coordinate system (calculated),
3. The zenith position of the sun in the global coordinate system (calculated),
4. The azimuth position of the SkyScan in local SkyScan coordinates (measured), and
5. The zenith position of the SkyScan in local SkyScan coordinates (measured).

The final two measured values (the local SkyScan coordinate values) will be the position of the axes on the SkyScan required to center the sun in the field of view. In general, the further the three data points are apart in the sky the better the calibration alignment will be.

Note
Avoid taking data points near the horizon because atmospheric refraction will potentially cause errors in the routine.

After the three data points have been captured they can be used to generate the transformation from the global coordinate system to local SkyScan coordinates.

5.2.2 Alignment Calibration Method

Before you can start an alignment calibration, the SkyScan must be running a heliostat mode trajectory. After it is running you will manually fine-tune the position of the SkyScan so that the sun is centered in the field of view of the system.

Important Information

In order to perform this calibration it is assumed that you have some way of imaging the sun and determining if the sun is centered in the devices field of view. Ideally the captured images would have vingetting from the SkyScan device so as to determine the center of the field of view.

1. Setup and run a heliostat trajectory that doesn't use the **Use Alignment Calibration** option. We want the trajectory to be run as if the SkyScan were perfectly aligned with the global geographic coordinate system. This trajectory should run for as long as a period as you can so that the three captured data points are spaced apart.
2. After the trajectory is running, click on the **Alignment Calibration** button on the **Utilities** pane of the **Ribbon Toolbar** to launch the **Alignment Calibration Dialog**.

Figure 18: Alignment Calibration Button

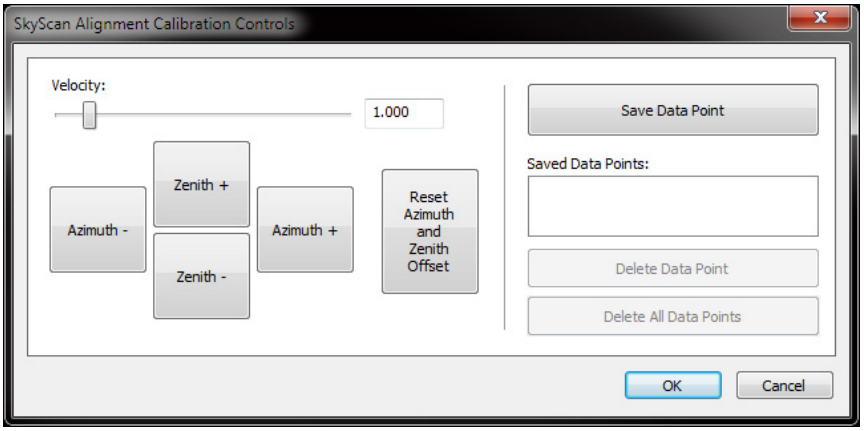

Figure 19: Alignment Calibration Dialog

This dialog provides velocity jog controls on the left side and data point management on the right side. The jog controls are to be used to manually apply an offset on top of the current trajectory.

3. Use the jog controls to position the sun in the center of the field of view. If there is a large misalignment and the sun isn't even in the field of view then it may require a bit of searching to find the sun. The **Reset Azimuth and Zenith Offset** button will reset the current trajectory offset to zero.
4. Once the sun is centered in the field of view, click the **Save Data Point** button. This will capture a data point and add it to the **Saved Data Points** list. The data points are listed by their timestamps.
5. Repeat steps 3 and 4 until you have 3 data points saved. The further apart these data points are the better the calibration alignment results will be. It is recommended that you choose the three points as follows:
    a. The first point should be as close to 10 degrees above the horizon (80 degrees zenith angle) while the sun is rising as you can get it.
    b. The second point should be sometime around the peak of the sun's path during the day.

c. The third point should be as close to 10 degrees above the horizon (80 degrees zenith angle) while the sun is setting as you can get it.

Note

The three data points don't need to be in the order listed above. As long as you have three data points that are spaced out spatially, the calibration will be valid. The data points don't even need to be on the same day – you could take the second one listed above on one day, the first one on the next day, and the third one a week later.

6. After the three data points are saved, click the **OK** button to close the dialog. If you click the **Cancel** button, any changes made to the data points in the dialog will be discarded.

As soon as the **Alignment Calibration Dialog** is closed, the new data points are used to construct the transformation (assuming you captured all three data points – if only one or two of them are captured then the software will continue to use a 1:1 transformation).

7. You can now stop the heliostat mode trajectory and start using the system.

6 Technical Support

In the event that you need technical support to troubleshoot a problem with the Keo SkyScan Control Software, please don't hesitate to contact us at support@keoscientific.com.

We also have a public issue tracker for this software product. Through this issue tracker you can view existing known bugs and feature requests and even add your own. We recommend creating an account so that you will be notified of any updates to the issues you post.

https://code.keoscientific.com/skyscan-control-software/issues

6.1 Contact Information

Keo Scientific's main office is located at the following address:

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